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HIGH TEMPERATURE BAG FILTER DEVELOPMENT

Arthur D. Little, Incorporated
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HIGH-TEMPERATURE BAG FILTER DEVELOPMENT

Final Report to
PUBLIC HEALTH SERVICE
DEPARTMENT OF HEALTH
EDUCATION, AND WELFARE

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I. SUMMARY

A. PURPOSE AND SCOPE

This investigation has been directed toward the development of a filter fabric possessing mechanical and temperature-resisting properties that would qualify it for use in conventional baghouse installations operating continuously at 600 F or higher. Temperatures of this order are often encountered in the effluent fumes of pyrometallurgical operations. The ultimate purpose of the program of which this study is a part is to develop an economical means of controlling dusts and mists in industrial stack gases, as an aid to air-pollution abatement.

The investigation has been conducted in four successive phases: (1) a review of the bag-filter equipment and fabrics now in use; (2) an evaluation of existing fibers and fabrics for the projected use; (3) the development of filter fabrics that would meet the expected conditions, including gas temperatures of 600 F and higher; and (4) upon the development of suitable candidate fabrics, the provision of sufficient quantities for adequate testing in pilot-plant-sized units at the Sanitary Engineering Center.

B. CONCLUSIONS

1. In conventional baghouse installations where the collected particulate is removed by intermittent shaking, bag life at elevated temperatures (i.e., above 600 F) depends on the following fabric properties: (a) thermal stability, (b) oxidation and corrosion resistance, (c) dimensional stability, and (d) internal (fiber-fiber) abrasion resistance.

2. Such performance factors as pressure drop, filtration efficiency, and ease of cleaning are secondary. For example, a fabric that has requisite tensile strength only as a thick pad and that proves unsuitable because of irreversible clogging is really failing because of poor dimensional stability at reasonable thicknesses.

3. Many fibrous materials can be screened for suitability on the basis of published physical data. Thus, organic fibers as a class have insufficient thermal stability.

4. Metal fabrics have not looked encouraging to date. Metal papers, metal screening, and wire felts have generally shown poor flexibility and insufficient oxidation and abrasion resistance; furthermore,

felt as a fabric form is not amenable to cleaning by shaking. The future development of fabrics from ductile high-temperature alloys with good stress-corrosion properties may ultimately alter this picture, particularly if the relatively new technique of bag collapsing proves generally applicable as a substitute for bag shaking.

5. At present, fibrous refractories have shown the most promise. Of the "untreated" refractory fabrics, premium-grade asbestos looks superior. Less resistant to internal abrasion are the lower grades of asbestos cloth, Fiberfrax (an aluminum silicate), Refrasil (a specially leached glass fabric), and Fiberglas. Except for the regular grades of glass cloth (Fiberglas), the last fabrics are costly enough to discourage very serious consideration.

6. To compare the internal frictional resistance of cloth samples at elevated temperatures, we have used two flexometers that we designed and built during the project. This equipment, which has gone through several model changes, has facilitated the laboratory evaluation of test fabrics and fabric treatments.

7. Fabric treatments designed to supply internal lubrication and thereby decrease abrasion between adjacent fibrils (as measured by the flexometer) have been especially effective for asbestos and glass cloths. Treatments have included impregnation with such recognized high-temperature lubricants as silicone oils and resins, as well as with graphite and molybdenum sulfide dispersions.

8. A graphite-impregnated glass cloth developed during this project performed so well in the laboratory flexural test and other tests that it was selected for pilot-scale evaluation at the Sanitary Engineering Center.

9. As an alternative to the use of expensive, high-temperature fabrics, the flue gas might be cooled by a water spray until its temperature permitted the use of intermediate-temperature fabrics. Problems of condensation and the feasibility of neutralizing acidic effluent should be carefully evaluated in each case.

10. The life of glass-fabric bags might be extended from about six months to two years by use of the intermittent collapsing techniques advanced by Menardi and Company and others for baghouse operations where shaking is not required; in fact, this may prove the only feasible method of employing glass-filter bags in the presence of abrasive fume.

11. The goal of bag-filter development should be a minimum bag life of 3-5 years if economical air-pollution abatement is to be achieved.

C. RECOMMENDATIONS

1. The Sanitary Engineering Center should check our laboratory findings concerning the effectiveness of the graphite treatment of glass fabrics. Initially, it would have to make fabric-shaking tests at room temperature. If successful, the tests should be repeated at elevated temperatures in the presence of iron oxide fume.

2. If the effectiveness of the graphite treatment is confirmed, field tests should be undertaken on a limited scale to determine the true behavior of a coated fabric and to study the possibility of retreatment in situ.

3. Concurrent with this field study, laboratory work should be pursued toward the development of more effective techniques for graphite application and retention, e.g., vacuum impregnation, and use of silicone greases.

4. If glass fabrics fail to survive the field tests, they should be replaced by Grade AAA asbestos treated with graphite.

5. Maximum use should be made of the technique of spraying water (or a neutralizing solution) into the flue gas stream to cool it and provide a measure of particulate coagulation before the gas enters a bag-filter installation.

6. Attention should be given to the possibility of cleaning bags without shaking them (i.e., by periodically collapsing them vigorously).

II. INTRODUCTION

The first report of our work on this subject, submitted on September 18, 1957, presented a literature survey of present bag-filter practice as it related to two major topics: (a) the filtration of dusts from hot gases, and (b) materials and equipment used in bag-filter installations. The period covered was 1952 to 1957; for especially pertinent material, earlier references were examined. In addition to providing a proper starting point for a materials development, the literature survey indicated the great importance of bag-filter equipment design to the economical use of filter fabrics. Moreover, it suggested an analysis of the costs of high-temperature fabrics versus gas cooling with more conventional fabrics. The importance of bag life to the economics of air-pollution abatement installations cannot be overemphasized; some authorities feel that a minimum bag life of five years is essential.

We began our experimental work by designing and fabricating a laboratory apparatus for comparing the flex life of fabrics at 600-900 F (see Progress Report 1 for a detailed description). We also used a standard DOP test apparatus for this project. Testing was initiated with various conventional high-temperature fabrics, including Grades AA and AAA asbestos, glass, and cotton duck (control). The development phase of the program followed two main paths: the evaluation of new fibers or of treatments for standard fibers, and the development of methods for treating available fabrics to improve their flexural strength at elevated temperatures.

Our second progress report, transmitted on May 29, 1958, dealt mainly with the second and third phases of the program. Many of the existing fibers were eliminated from further consideration on the basis of their known physical and chemical characteristics. For example, the requirement of a minimum operating temperature of 600 F disqualified all organic fibers, including Teflon.

We then developed standard laboratory testing techniques that were uncomplicated but yet indicated the relative effects of temperature and severe flexing on test samples. We felt that such simulated-performance testing ought to show a reasonable correlation with field performance, and would at least eliminate obviously unsuitable fiber materials from further consideration in this program.

Attention was given to a wide variety of fibrous refractory materials, such as stainless steel, brass, carbon filaments, asbestos, glass, aluminum silicate, and fibrous blast-furnace slag (rock wool). After this initial screening, we decided to focus our efforts on glass and asbestos fibers as the most promising materials for bag-filter applications.

Tests carried out in the original flexometer, and in an apparatus designed to operate at 800, 900, and 1000 F (see Section III), showed that asbestos fabrics (Grades AA and AAA) were quite superior to untreated glass fabrics. Our interest in asbestos was diminished, however, with the realization that the best results were being obtained only with the highest-priced grades. Although DOP tests showed that the asbestos fabrics exhibited two to three times the pressure drop of many glass fabrics, this fact in itself was not a major consideration, for bag-filtration efficiency depends more on the nature of the filter cake itself than on the fabric. The relative difficulty of cleaning the asbestos fabrics was of greater importance.

At this point we were convinced that our original suspicions were correct and that the short flex life of glass fabrics at 600 F and higher was basically a fiber-lubrication problem. The silicone lubricants used on glass yarns are not designed to cope with the internal abrasive action accompanying this flexing test; moreover, most silicone oils are volatile or subject to decomposition in this temperature range. More resistant silicone resins are sometimes used. The lubrication requirement was confirmed by the great improvements in flex life that resulted when special lubricant coatings were used. For example, one sample of glass cloth (Criswell 45420) showed a tenfold increase in flex life at 600 F after impregnation with a graphite dispersion (Acheson's Dag 41). Asbestos fabrics were benefited to a lesser degree.

In our recent investigations, we have sought to follow up this important finding as a principal part of the third phase of this program. This final report does not reiterate all the factual matter of the first two progress reports. Instead, it presents the experimental results obtained since the last report, coupled with a survey of all data leading into our Phase IV effort. However, the conclusions and recommendations in the foregoing Summary are based on the findings of the entire investigation.

III. TEST METHODS

A. HIGH-TEMPERATURE FLEXOMETER

The items of test apparatus developed for the purpose of fabric evaluation are shown in Figure 1. They were designed to permit a rectangular sample 1-3/4 inches wide by 6 inches long (the long dimension is in the direction of the weave) to be slowly moved back and forth across a 1/8-inch-diameter polished roller while a stream of heated air was blown on the contact point between the fabric and the roller. The reciprocating action of the motor produced a flexing rate of 41 cycles per minute (travel 1.6 inches, speed 11.1 feet per minute). Constant tension on the sample was provided by a 3-pound weight. Heating was accomplished by means of a cone resistor and a small blower unit directing a down-draft stream of heated air. Instrumentation included an iron-constantan thermocouple situated above the roller, and a revolution counter on the motor. The test device was covered by a readily removable transite box provided with viewing windows. Temperatures of 600 F to 700 F were reached in about 10 minutes without supplemental insulation. With external insulation, a temperature of 900 F was attained after 15-20 minutes of heating.

In the second flexometer, we placed the bearings for the 1/8-inch polished roller outside the test chamber itself, by cutting holes in the chamber wall and placing a set of insulated external supports on each side of the chamber. With the addition of two 250-watt cone heaters to supplement the heated air passing through the fabrics, test temperatures of 1000 F were attainable. Because of the greater distance between the bearings in the second apparatus, the 1/8-inch stainless steel shaft tended to whip somewhat. However, comparative runs of the two testers did not indicate any serious difference in performance. The second apparatus is shown on the right-hand side of the first apparatus in Figures 1 and 2. An interior view of the second apparatus is shown in Figure 3.

B. DOP FILTERING-EFFICIENCY TEST

In addition to the tests for determining flex life at high temperatures, some of the fabrics were subjected to a standard DOP (dioctyl phthalate) test in which superficial filtering efficiency and pressure drop were measured for a 3/10-micron aerosol. We regard such measurements as only roughly indicative of the behavior of these fabrics in actual

practice, where the pressure drop and efficiency of a bag filter are determined largely by the layer of granular material that builds up on its surface. In the case of the DOP test, no particulate is involved; instead, an oily aerosol that does not build up a cake is used. This test has been of most value here for the rapid comparison of initial filtration values.

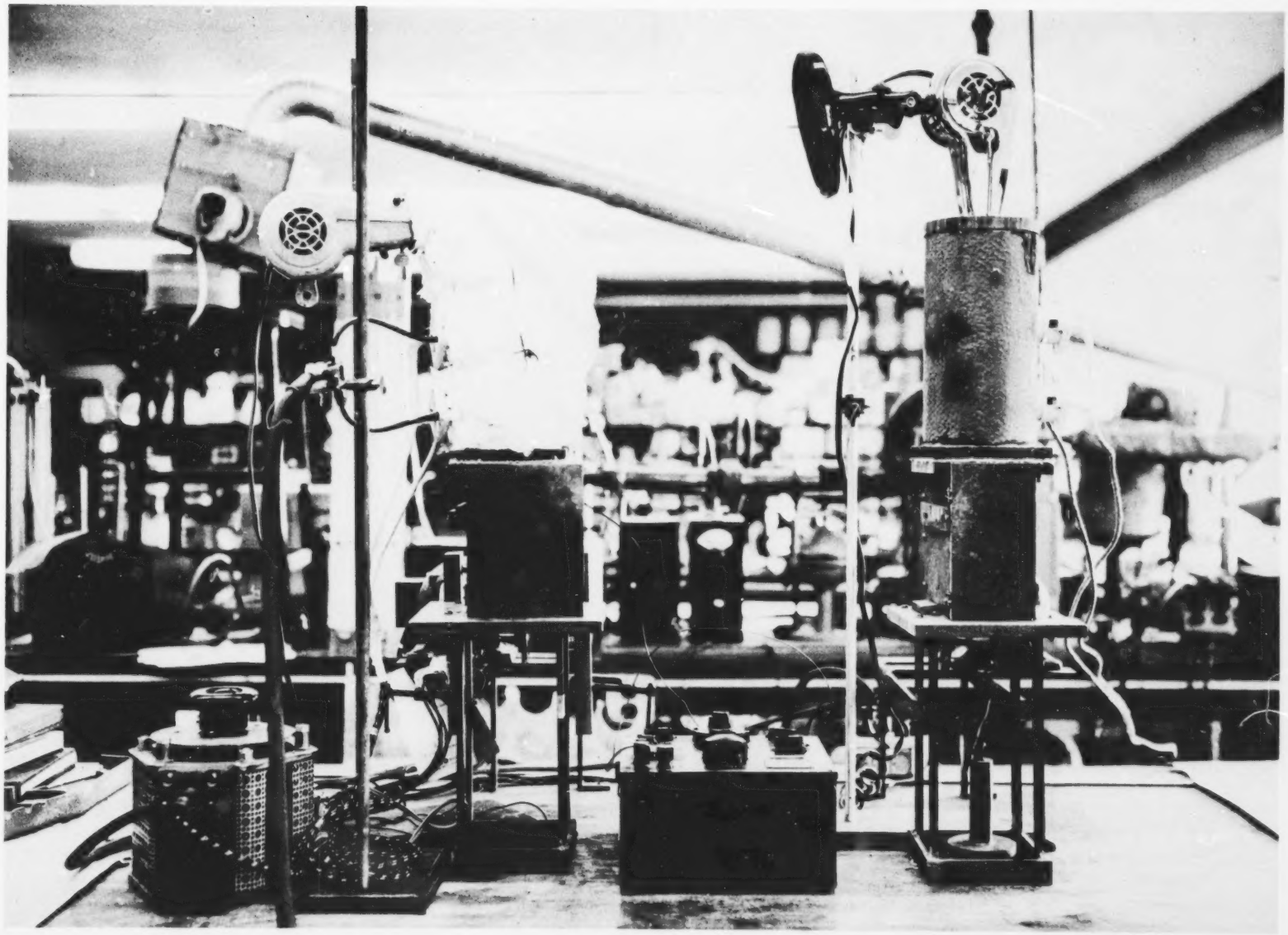

Figure 1
FRONT VIEW OF FABRIC FLEXURAL TESTERS NO. 1 AND NO. 2

(No. 1 on the left.)

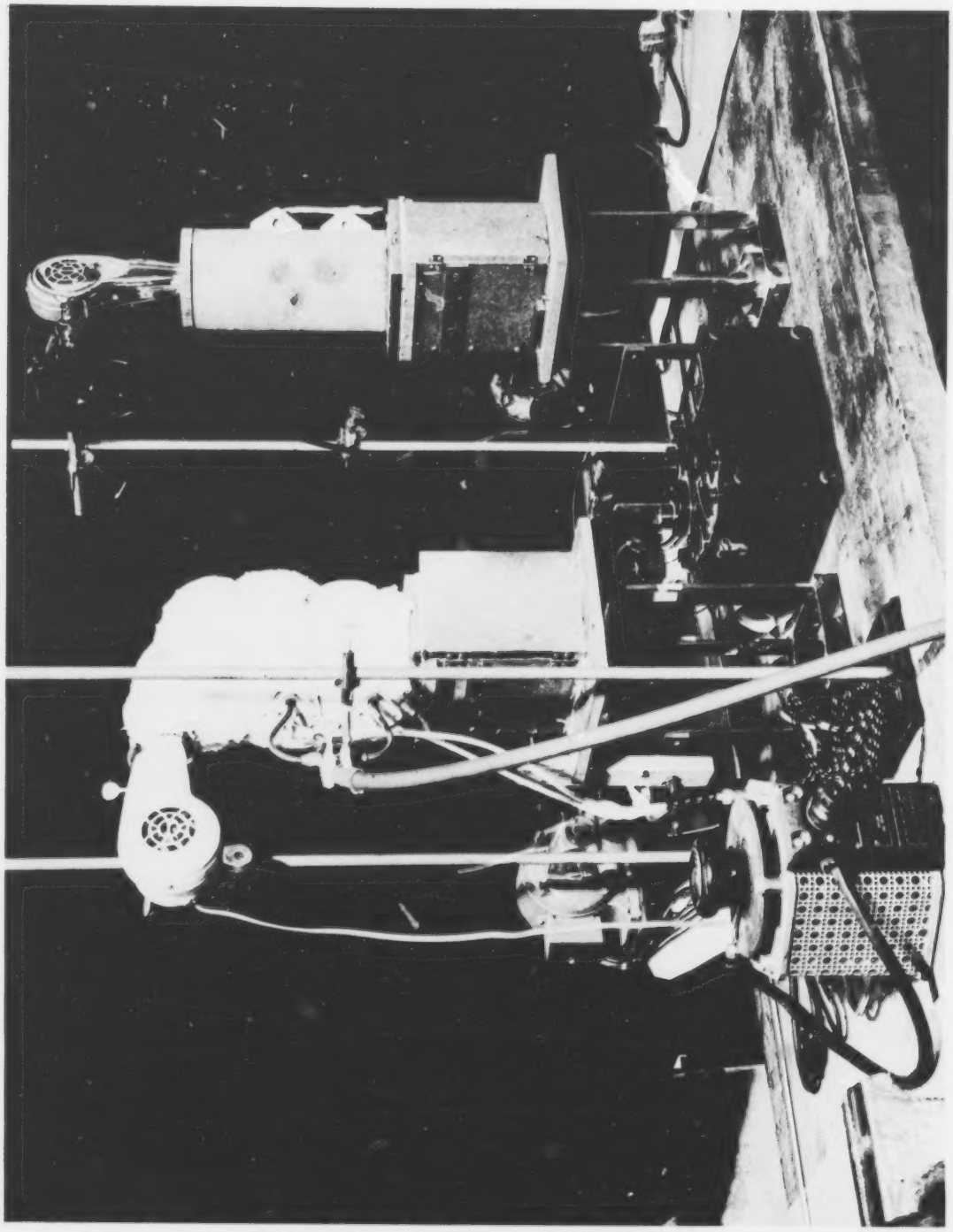

Figure 2

OBLIQUE VIEW OF FABRIC FLEXURAL TESTERS

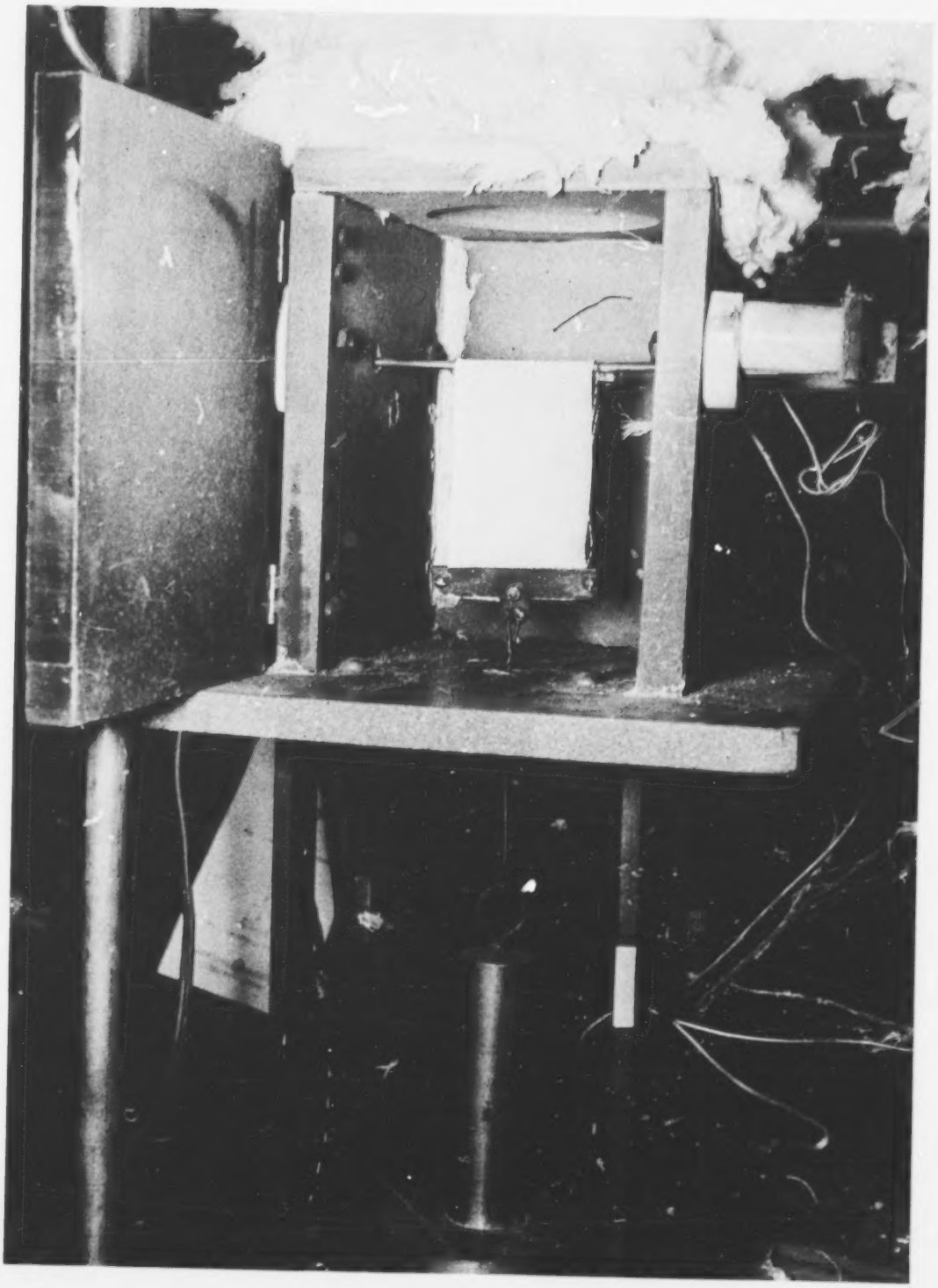

Figure 3
INTERIOR VIEW OF FABRIC FLEXURAL TESTER NO. 2

IV. COMMERCIAL FABRICS

Samples of most of the commercial fabrics worthy of consideration here have already been evaluated and reported on. Consequently, only asbestos, glass, steel wool, and aluminum silicate fabrics have received much recent attention. In fact, our effort lately has been focused on fabric treatments, especially for glass. Table I lists the flexural-test results obtained for commercial fabrics since our last report.

A. GLASS

1. Fiberglas

The remarkable improvements we observed earlier for glass fabrics lubricated with graphite dispersions (Oildag, Dag 41, etc.) have prompted us to treat a number of commercial glass fabrics with these materials. The outstanding performer in the Fiberglas series offered by W. W. Criswell Co. has been Style 45300, a grade with no silicone lubricant on its surface. When silicone textile lubricants decompose thermally, abrasive deposits of silicon dioxide often remain to chafe the fibrils and reduce bag life. Our tests suggest that the absence of such a lubricant is preferable to having it present in an environment where it will decompose. Such decomposition may explain the short test life observed for the other two Criswell fabrics, 45320 and 45420, which we understand are sized with a silicone resin.

2. Maco-Glas

Rather recently, we have obtained both fabric and bag samples from Menardi and Company (El Segundo, California). Its standard glass fabric 501/54 PK has shown a relatively long life in our flex test (10-16 hours at 600 F). Much less impressive have been the test results with fabric 313-A (5-6 hours at 600 F); ironically, this is a premium item developed to withstand shaking.

With glass fabric, according to Menardi and Co., the temperature limit in filtration depends not so much upon the glass itself as upon its finish--a view with which we concur. When a silicone is applied to the annealed, heat-treated, surface-active glass cloth, it bonds chemically to the glass to give a lubricating, heat-resistant, chemically inert finish. A methylpolysilane fluid is used in the company's "Maco process."

TABLE I

EVALUATION OF COMMERCIAL FABRICS

Test No.	Manufacturer and Style Number	Distinguishing Feature	Test Temp. (°F)	Time To Failure (hours)		Remarks
A. GLASS						
200	W. W. Criswell Co. 45300	No silicone coating	600	23.2)	23.1	"Grey goods"
218	W. W. Criswell Co. 45300		600	23.0)		
22	W. W. Criswell Co. 45320	16 oz/sq yd	600	0.4		
198	W. W. Criswell Co. 45420	17 oz/sq yd	600	2.5)	2.4	
217	W. W. Criswell Co. 45420		600	2.2)		
221	Menardi & Co. 313-A	Maco finish, designed	600	4.5)		
222	Menardi & Co. 313-A	for shaking operations	600	5.7)	5.5	
224	Menardi & Co. 313-A		600	6.1)		
225	Menardi & Co. 313-A		600	5.6)		
223	Menardi & Co. 501/54PK	Maco finish, standard	600	10.3)	13.3	
226	Menardi & Co. 501/54PK	bag-filter fabric	600	16.3)		
B. ASBESTOS						
100	Union Asbestos & Rubber Co. A5301	Grade AAA	600	3.6		

TABLE I (Continued)

Test No.	Manufacturer and Style Number		Distinguishing Feature	Test Temp. (°F)	Time To Failure (hours)	Remarks
C. ALUMINUM SILICATE (Fiberfrax)						
208	Carborundum Co.	102T	32 oz/sq yd	600	0	
209	Carborundum Co.	102T		600	0	Sample cut opposite direction
210	Carborundum Co.	102T		600	0	Repeat of test 208
211	Carborundum Co.	157C-T	Contains wire cores	600	>2.0	Sample stretched, not broken
212	Carborundum Co.	157C-T		600	1.5	Sample broke properly
213	Carborundum Co.	157C-T		600	0.3	Sample cut opposite direction
214	Carborundum Co.	144AW-T	High-temperature fabric	600	0.2	
215	Carborundum Co.	157C-T	Low-temperature fabric	600	0.2	

B. STEEL WOOL

An experimental filter material based on steel wool was evaluated and will be described in this section, since it could be readily fabricated from conventional materials. Supplied to us by Advance House (Philadelphia), the filter material consisted of two concentric cylinders of galvanized-wire screening (18 mesh) soldered at the edges and separated by about a quarter of an inch of steel-wool packing. Over-all dimensions measured about 38 inches by 4-1/2 inches (diameter). This sample was designed to simulate the mechanical behavior of a similar material made of stainless steel wool.

We designed and built an apparatus that would shake a 3-inch by 6-inch swatch of this material at 600 F. The sample was attached vertically via clamps to a 3-pound load, and oscillated over about a 1/2-inch amplitude. Tests with this apparatus proved inconclusive, for no evidences of sample failure occurred after a reasonable period (12 hours) either with the Advance House sample or the control (Criswell's 45420 Fiberglas, untreated). Several minor modifications increased the test severity until signs of incipient failure were finally evident (for both sample and control) within a 12-hour period. However, this approach was abandoned since it was time-consuming without being very conclusive.

We then devised a simple test in which the test specimen was clamped in a vise against a horizontal 1-inch pipe. Failure occurred after about 8 minutes of a back-and-forth motion (90° angle, 3-inch amplitude) against the pipe. The control appeared unaffected after a 15-minute test.

C. ALUMINUM SILICATE

Aluminum silicate fiber has a melting point of over 3000 F, and a maximum use temperature of 2300 F. When exposed to temperature in excess of 2000 F for long periods of time, the material undergoes devitrification--i.e., the amorphous or random crystalline orientation changes to a definitely arranged pattern. Long staple fibers of controlled diameters are produced by a recently developed process in which small quantities of zirconia are added to control the melt.

Four styles of Carborundum Company's Fiberfrax evaluated (see Table I) in the flexometers showed virtually no abrasion resistance under the test conditions. We believe that even if this deficiency could be rectified with a suitable filament lubricant, as noted for asbestos and glass, the very high cost of Fiberfrax would make it less attractive than glass, at least for general use at temperatures below 700-800 F.

V. FABRIC TREATMENTS

A. GRAPHITE DISPERSIONS

Graphite dispersions were examined as treating agents after molybdenum sulfide had proved ineffective at elevated temperatures because of its oxidation susceptibility. Their use was further suggested when it was observed that carbon formed in situ by thermal decomposition appeared to confer a slight improvement on oil-impregnated fabrics (see test 169). Various graphite dispersions were obtained from Acheson Colloids Company (Port Huron, Michigan). All these products greatly improved the high-temperature durability of glass cloth. Two earlier tests (runs 119 and 114) with graphite-treated asbestos cloth indicated a similar improvement. These tests showed that Dag 41 and Oildag were the best dispersions for this application.

1. Oildag

We have reported significant improvements in flex life through the use of Oildag (concentrated). This product, a liquid dispersion of 10% colloidal graphite in petroleum oil (meeting Federal Specification MIL-L-3572, Grade B), has been applied here mostly as the concentrate (10% solids); where desired, dilutions have been made with a naphtha diluent. For the sake of consistency and effectiveness we have adopted the standard practice of using a hand wringer to squeeze out the excess impregnant and then oven-curing the treated fabric.

Section A of Table II lists all our recent results with glass cloth, including Oildag treatments. Except for those treatments which included silicone resin (see Section B below), recent test results with Oildag have not looked so promising as those obtained with Dag 41.

2. Dag Dispersion 41

Acheson Colloids Company's Dag 41 is similar to Oildag in that it is a dispersion of 10% colloidal graphite in a hydrocarbon solvent. As a solvent, Oildag uses a relatively nonvolatile oil whose complete removal from impregnated fabrics requires several hours at elevated temperatures. Dag 41 uses a volatile, lacquer-diluent naphtha that evaporates rapidly under ambient conditions and requires only brief heating for complete removal. It was developed primarily as a processing aid for the drawing, extruding, and stretch forming of aluminum and magnesium.

TABLE II

EVALUATION OF FABRIC TREATMENTS

Test No.	Manufacturer & System No.	Fabric Treatment	Retention (Wt.-% of Init. Wt.)	Test Temp. (°F)	Time To Failure (hours)	Remarks
A. GLASS						
201	W. W. Criswell Co. 45300	Dag 41, air-dried	4	600	41.7)	
219	W. W. Criswell Co. 45300	Dag 41, air-dried	-	600	61.2) 52.0	
220	W. W. Criswell Co. 45300	Dag 41, air-dried	6	600	53.2)	
204	W. W. Criswell Co. 45300	Dag 41, 12-days at 700 F	-1	-	--	
205	W. W. Criswell Co. 45300	GE Silicone resin 81754	-	600	5.7	
202	W. W. Criswell Co. 45300	GE Silicone & Dag 41	-	600	45.0	
207	W. W. Criswell Co. 45320	Dag 41, oven-dried	-	600	14.8	Sample of cloth sent to Criswell for bag fabrication
172	W. W. Criswell Co. 45420	Conc. Oildag, 1 week in 700 F oven	-	700	1.1) 1.9	
173	W. W. Criswell Co. 45420	Conc. Oildag, 1 week in 700 F oven	-	700	2.6)	Duplicate of 172
176	W. W. Criswell Co. 45420	Conc. Oildag (dusted with iron oxide)	-	700	1.0	
174	W. W. Criswell Co. 45420	Dag 41, 1 week in 700 F oven	-	700	8.0) 8.4	
175	W. W. Criswell Co. 45420	Dag 41, 1 week in 700 F oven	-	700	8.7)	Duplicate of 174
177	W. W. Criswell Co. 45420	Dag 41 (dusted with iron oxide)	-	700	2.6	
170	W. W. Criswell Co. 45420	20% iron oxide in mineral oil	8	80	1.5	

TABLE II (Continued)

Test No.	Manufacturer & System No.	Fabric Treatment	Retention (Wt.-% of Init. Wt.)	Test Temp. (°F)	Time To Failure (hours)	Remarks
171	W. W. Criswell Co. 45420	Iron oxide dry-worked into cloth	14.5	80	1.6	
178	W. W. Criswell Co. 45420	10% Oildag + DC resin 2106	-	600	7.1	Oven-cured as 172
179	W. W. Criswell Co. 45420	Conc. Oildag + DC resin 2106	-	600	9.1) 7.7	" " " "
181	W. W. Criswell Co. 45420	Conc. Oildag + DC resin 2106	-	600	6.4)	Treatment cycle repeated
180	W. W. Criswell Co. 45420	10% Dag 41 + DC resin 2106	4	600	5.7	Oven-cured as 172
184*	W. W. Criswell Co. 45420	Duplicate of 172	-	700	(0.03)	Roller may be sticking
193	W. W. Criswell Co. 45420	10% Oildag, 440 F for 2 hours	7	600	2.6	
194	W. W. Criswell Co. 45420	10% Oildag + DC 2106	3.5	600	2.7	Oven-cured as 193
195	W. W. Criswell Co. 45420	Dag 41, 440 F for 1 hour	5.5	600	> 9.5	Sample stretched, not broken
196	W. W. Criswell Co. 45420	Dag 41 + DC 2106	-	600	2.3	Oven-cured as 193
197	W. W. Criswell Co. 45420	10% Mica in 2% Methocel solution (aq.)	4.5	600	2.5	Air-dried
199	W. W. Criswell Co. 45420	10% Mica in 0.1% Polyox solution (aq.)	8.0	600	1.5	Air-dried
216	W. W. Criswell Co. 45420	Dag 41, 440 F for 1 hour	-	600	8.7	Compare with 195
B. ASBESTOS						
169	Union Asbestos & Rubber Co. A5301	20% Iron Oxide in Mineral Oil	23	600	>53.8	Clamp failed before sample

* Runs number 185-192 are omitted because of roller sticking (bearing failures).

Our current test results with Dag 41 are summarized in Section A of Table II. The most outstanding improvement in high-temperature durability is seen for Criswell's 45300, where the test result increased from 23 to 52 hours. With Criswell fabrics 45320 and 45420 the percentage improvement is even more impressive, though much lower on an absolute scale than with 45300 (compare tests 200, 22, and 198 with 220, 207, and 175, respectively).

B. SILICONES

Silicone resins have been applied in this investigation in two ways: (1) to strengthen fabrics, such as asbestos or Fiberfrax, that are heat-resistant but deficient in mechanical properties, and (2) to assist in the retention of a particulate solid-phase lubricant, such as graphite, on the fabric.

1. Fabric Reinforcement

One resin that has shown promise for the strengthening of asbestos fabrics in high-temperature service is Dow Corning's 805. Discussed in detail in the previous report, this temperature-resistant resin imparted great improvement, at treating levels above 2%, to Grades AA and AAA cloths in usage at 600 F and 700 F. A treating level of 5-10% appeared most feasible for any practical consideration.

2. Lubricant Adhesion

Used as a means for "cementing" graphite lubricants in place, silicone resins have given conflicting results. With Criswell's 45420 Fiberglas treated with Oildag concentrate, flex test life at 600 F was increased from about 3 hours to almost 8 hours by the topcoating of the graphited fabric with Dow Corning's 2106. When Dag 41 was used in place of Oildag, however, no significant improvement followed the use of DC 2106.

In a set of tests using Criswell's 45300, the flex time at 600 F was actually reduced slightly (from 52 to 45 hours) when General Electric resin 81754 was introduced as a 10% additive (solids basis) into the Dag 41 treating solution. The addition of a few percent of compatible silicone fluid (GE 81705) to serve as a low-volatility plasticizer in the above formulation made no improvement in the test result.

C. ABRASIVE DUSTS

The reduction of bag life by the action of abrasive particulate must be considered in a filter-fabric development of this type. Various metallic-oxide dusts are commonly encountered in the gaseous effluent of metallurgical operations. By virtue of their shape and hardness, some of these potential air pollutants represent a real threat to bag life unless practical means of fabric protection are developed. Moreover, the fabrics toward which the thermal requirement of this problem has directed the solution--i.e., ceramics--are especially susceptible to dust abrasion. Most of the protective measures designed to overcome external abrasion may be grouped under lubrication, or barrier coatings, or some combination of the two.

We have been hopeful that lubrication with graphite dispersions, so successful in overcoming internal abrasion, would confer a reasonable measure of protection against external (dust) abrasion as well. But when rouge (submicron iron oxide) has been dusted onto glass fabrics prior to testing, the level of improvement of graphite-lubricated fabrics at 600-700 F has been reduced considerably. We have addressed our attention to iron oxide because of its pertinency to the ultimate objective of this program. Comparison of the test results from runs 170, 171, 176, and 177 (see Progress Report 2) with their corresponding controls illustrates the deteriorative effect. Some attention should be called to the fine performance observed in test 169, where asbestos cloth treated with 20% iron oxide in mineral oil went beyond 54 hours.

Mica powder (finely ground) and talc were applied to test fabrics from wettable dispersions in the expectation that they might provide an enduring form of lubrication. Inspection of the test data (77, 117, 197, 199) will reveal that they behaved more like abrasive dusts.

The results of this program suggest that further attention be given to the exploration of the alternative protective measure of a barrier coating (to control external abrasion) coupled with an effective fiber lubricant (to reduce internal abrasion). Successful application of this technique may depend on the development of improved high-temperature protective coatings.

VI. EXPERIMENTAL BAG FILTERS

For the last phase of this program it has been our responsibility to furnish experimental bag filters in proper quantity for adequate testing and evaluation in pilot-plant-sized units at the Sanitary Engineering Center. In meeting this materials requirement, we have made use of our new Waldron multipurpose reverse-roll coater and two-stage drier for the preparation of graphite-impregnated glass cloth.

Several glass-and-asbestos fabric and bag-filter manufacturers have offered to produce pilot lots of any fabric developed in this study. We have been pleased to accept the cooperation of two such companies: the W. W. Criswell Company (611 North 15th Street, Philadelphia, Pennsylvania) and Menardi and Company (1222 East Grand Avenue, El Segundo, California).

The Criswell Company worked with us on the fabrication of experimental bag filters. Using Criswell's 45420, we conducted the fabric treatments in our coating laboratory (Dag 41, 30 minutes at 400 F) and then returned the treated cloth to Criswell for bag fabrication according to the Sanitary Engineering Center specifications.

Menardi and Company supplied several types of filter bags to the Sanitary Engineering Center and provided us with corresponding fabric samples for the high-temperature-flex test (see Table I). The company maintains that its Maco-Glas fabric bags can be operated successfully at temperatures as high as 800 F. No shaking mechanism is used, and the bags clear themselves by a simple collapse at regular intervals. While such bags are probably unsuitable for installations where shaking is required, they may have some place in this program. In fact, this may prove to be the only feasible method of employing glass-filter bags in the presence of abrasive fumes and dusts.